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ANNUAL LETTER REPORT-JSE-15-90

Dear Dr. Barsoum:

Please find enclosed an "Annual Letter Report" as required under the deliverables schedule for ONR Contract N0014-88-K-0496. I would also like this short letter to serve as a quarterly update since my last communication with you in January 1990. In brief, during the past year we have examined the local near tip asymptotic fields and toughening mechanisms for 3 classes of flawed ceramics, (i) nominally pure alumina as a function of grain size form 20-150 microns (Al_2O_3), (ii) Partially Stabilized Zirconia (Mg-ZrO_2) and (iii) hot pressed SHS Titanium Diboride (TiB_2). Class (i), in joint cooperation with General Electric Co. investigates the nature and existence of microcracking as a mechanism to toughen ceramics. Using moire interferometry we have identified that microcracking exists below grain sizes on the order of 70 microns. Above 70 microns we have identified that crack deflection occurs along the grain boundaries and acts as the principal toughening agent. For class (ii), in joint cooperation with Oak Ridge National Laboratory, we have produced for the first time, local in plane asymptotic fields, as well as wake zones for the tetragonal to monoclinic phase transformation surrounding a propagating crack. The ultimate goal of studying classes (i) and (ii) is to understand the fracture behavior for the two phase system of Al_2O_3-ZrO_2. For class (iii), in cooperation with GTRI, we have identified that the toughening occurs by crack branching. The principal tools of investigation have been direct tensile loading of miniaturized DCB specimens optimized for straight crack growth using a small high compliance load frame which can open the crack mouth 0.2 microns in resolution, acoustic emission for microcrack activity and moire interferometry for X and Y displacement fields local to the crack tip. We are currently applying for a patent on the high compliance load frame. In addition we are using white light microscopy for direct counting of microcrack density before and after testing of the Al_2O_3. You currently have overheads that describe the outlined work performed over the past year as an additional deliverable.

As a short quarterly report, during the past 4 months since the January report and overheads, we duplicated the above test results. This has involved retesting all 6 alumina specimens as a function of grain size as well as the single ZrO_2 specimen. We already have duplicated results on the TiB_2. We are know beginning to produce R curves for the alumina and Zirconia. Out initial results on the Zirconia show a rise in R curve behavior consistent with the theoretical work of Stump and Budiansky. This rise effect is quite novel and relates to the initial expansion of the phase transformation zone. We are developing local mixed mode K_I and K_{II} extraction algorithms from the local moire data as the fracture of the alumina at larger grains sizes occurs by local crack deflection and hence local mixed mode behavior. The crack branching in the TiB_2 also exhibits similar effects. These results are quite interesting as normal screening and material testing results are assumed under mode I conditions. I am expecting that this work should be completed by the end of July.

Finally due to budget reductions on this program we have deleted all dynamic aspects of crack growth as the future increments were intended to begin this phase. In this manner, we may produce higher quality results on static crack growth with the remaining money. Our budget currently is projected through December 1990 at which time the last student working on this program will have finished his thesis. At that time I will begin to write up the final report.

Sincerely

Jonathan S. Epstein

STATEMENT "A" per Dr. R. Barsoum
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TELECON 5/6/90 VG